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INVENTORS: Osamu Sakai
Keiji Takagi

TITLE: SUBSTRATE HAVING REPAIRED METALLIC PATTERN AND METHOD AND DEVICE FOR REPAIRING METALLIC PATTERN ON SUBSTRATE

ATTORNEY: Gustavo Siller, Jr.
BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, ILLINOIS 60610
(312) 321-4200

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TITLE OF THE INVENTION

SUBSTRATE HAVING REPAIRED METALLIC PATTERN AND METHOD AND DEVICE FOR REPAIRING METALLIC PATTERN ON SUBSTRATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a substrate, such as a glass substrate, used for a liquid crystal display device and having a repaired defect in a metallic pattern or a mask of a semiconductor formed on the substrate and, and a method and a device for repairing the metallic pattern or the mask of the semiconductor on the substrate.

2. Description of Related Art

In recent years, a matrix type display device using a liquid crystal has been used widely as a display device used for a computer instead of a display device using a cathode ray tube. Further, to increase data displayed on a screen at one time, a liquid crystal display device or a plasma display device having a large screen or high definition has been developed. This has reduced a yield and has increased defective substrates and hence the defective substrates has been repaired to reduce costs of liquid crystal display device.

An ordinary matrix type liquid crystal substrate is formed by forming transparent X and Y electrodes comprising ITO on two glass substrates by etching and by arranging the substrates

opposite to each other with the electrodes-formed planes in a matrix and by filling between the glass substrates with liquid crystal. When the X electrodes or the Y electrodes are formed on the substrates as described, the defects shown in FIG. 9 are produced sometimes by mixed foreign matter or by etching. FIG. 9A shows a good product and FIG. 9B shows a short-circuited defect in which neighboring lines are joined to each other and FIG. 9C shows a broken (open) defect in which a line is broken.

To repair the short-circuited defect shown in FIG. 9B, a short repair device, that is, a device for cutting a short-circuited part by laser lays has been used.

To repair the broken defect shown in FIG. 9C, the following methods have been disclosed, that is;

(W) an organoindium compound solution is applied to the broken defective part and then is heated to transform the applied film of the organoindium compound into a conductive layer (Japanese Unexamined Patent Application No. 3-85523),

(X) a conductive liquid glass is applied to a defective part of a transparent electrode. (Japanese Patent Application Laid-Open No. 2-67517),

(Y) an adhesive comprising plastic fine particles is applied to a broken defective part of a bump (Japanese Patent Application Laid-Open No. 2-301723),

(Z) a conductive material is applied to a broken defective part and then laser rays are applied thereto.(Japanese Patent

Application Laid-Open No. 2-301723).

However, the above-mentioned techniques disclosed in (W) to (Z) have the following drawbacks.

The method disclosed in (W) has a problem that indium used as metal for joining is oxidized when it is heated for forming a conductive layer to have a detrimental effect on electric characteristics and to produce a large amount of heat.

The method disclosed in (X) has a problem that a conductive glass used for repairing the broken defective part of the electrode produces large resistance and a large amount of heat in the repaired defect. Similarly, the method disclosed in (Y) has structural problems that resin containing conductive fine particles produces large resistance and a large amount heat in the joined part and that a coated film needs to be thick so as to realize a stable joining state.

The method disclosed in (Z) has a problem that a device referred to as a YAG laser for heating the conductive material is large in size and troublesome in handling and a problem in quality that because the output of the device can not be freely controlled, the conductive material is rapidly baked and cooled to produce cracks in the repaired part. A carbon dioxide laser instead of the YAG laser has been used for baking, but any of them has advantage and disadvantage from the viewpoint of a life of laser and handling of laser.

Further, since a line of a transparent electrode formed

on the substrate of the liquid crystal display device is very small in width and in thickness, when the above-mentioned organoindium compound, the conductive glass or the adhesive containing conductive fine particles are used, it is difficult to make the joined part very thin and even if the joined part can be made thin, the quality of the joined part is not ensured because cracks are produced in the joined part.

Furthermore, when the transparent electrode is formed on the substrate of the liquid crystal display device, a resist material is applied to a thin film and is exposed to light by using a mask and is developed to form a resist pattern and then the above-mentioned thin film is etched according to the resist pattern to form a transparent electrode having a predetermined pattern. In this regard, if the above-mentioned mask has a defect, the pattern formed on the transparent electrode also has a defect. The lightproof film of the above-mentioned mask has sometimes a defect and when the defect is repaired, the above-mentioned problems are also produced.

Still further, if the pattern of a mask substrate for forming a semiconductor has a defect, the pattern is so fine that it is hard to repair the defect and hence the mask substrate is scrapped. However, in recent years, it has been required that the defective pattern of the mask substrate be repaired to use the mask substrate for reducing costs.

SUMMARY OF THE INVENTION

The present invention has been made to solve the above-mentioned problems. An object of the present invention is to provide a substrate having a repaired metallic pattern which can prevent the repaired defective part from generating heat and does not produce cracks in the repaired defective part by repairing a broken defective part of an electrode formed on a glass substrate of a liquid crystal display device and a defect of a lightproof film of a mask by a thin film having good electric characteristics, that is, low electric resistance and good quality, and a method and a device for repairing a metallic pattern on a substrate.

A substrate according to the present invention has a repaired metallic pattern whose defective part is repaired by applying a conductive material thereon, wherein the defective part is repaired by a thin film of metal deposited from a metallic organic compound.

If the above-mentioned metallic pattern is an electrode, the metallic organic compound is applied on the defective part and then is heated to dissipate an organic component in the organic compound, whereby a thin film comprising only a metallic component is formed. Therefore, a defective part in the electrode formed on a liquid crystal substrate and having a very narrow width and a thin thickness can be repaired by forming a thin film whose cross sectional area is equal to or less than

that of the electrode.

In this respect, the glass substrate of the liquid crystal display device is typical of the substrate according to the present invention, but the present invention can be used for the other substrate on which an IC is formed. Further, the electrode is the transparent electrode such as ITO in the case of the liquid crystal display device, but it may be the other copper foil electrode or the gold foil electrode.

Further, the above-mentioned metallic pattern may be a lightproof film. The lightproof film can be applied to a mask for forming an electrode pattern on the glass substrate or to a mask substrate for forming a semiconductor. The lightproof film like this is formed on the glass substrate by a metallic pattern comprising chromium and is used as the mask. In this case, when a defective part is produced in the lightproof film, it is repaired by the above-mentioned means and then a part sticking out from the metallic pattern of the lightproof film is removed. The mask formed in this manner is placed on the electrode substrate on which a resist layer is formed and then is exposed to light and is developed to form a pattern of the resist layer, and then an electrode part is removed by etching according to the resist pattern to form a high dense electrode pattern on the substrate.

In the case described above, it is preferable that the above-mentioned organic compound is gold-resinate-based paste

for low temperature baking. If the defective part of the substrate is repaired by a gold thin film by using this paste, the defective part can be made extremely conductive as compared with the defective part repaired by a conventional repairing material such as conductive resin. Therefore, the defective part does not produce heat and hence can prevent the glass substrate from suffering damage by heat.

A method for repairing a metallic pattern on a substrate according to the present invention comprises steps of applying a metallic organic compound to a defective part in a metallic pattern formed on the substrate, and heating the organic compound to deposit a metallic thin film in the defective part.

It is preferable that a semiconductor laser is used as a heating source for baking the above-mentioned metallic organic compound, and that the output of the semiconductor laser is adjusted to provide a baking process comprising a heating process of provisional baking and main baking and a cooling process.

A metallic thin film of metal deposited from the metallic organic compound is formed as a dense metallic layer by the above-mentioned techniques according to the present invention. Although the metallic thin film is very thin, it can have stable electric characteristics.

Further, since the above-mentioned paste is black and the above-mentioned semiconductor laser is used, only the paste formed in the broken defective part absorbs laser light and is

heated and the other part does not absorb the laser light and is not heated. Therefore, the glass substrate other than the defective part does not suffer damage caused by heat.

Further, according to the present invention, it is preferable to provide a removing process for removing a part sticking out from the metallic pattern of a thin film made of deposited metal.

The metallic pattern can be used as a mask of a lightproof film by the above-mentioned removing process, and the metallic thin film deposited after heating and sticking out from the pattern can be removed to form a mask having a metallic pattern of high quality.

Further, a device according to the present invention for repairing a defective part in a metallic pattern formed on a substrate is provided with a receiving part for holding a metallic organic compound thereon, a transfer body moving between the receiving part and the defective part in the electrode and transferring the metallic organic compound held on the receiving part to the defective part, and a semiconductor laser for baking the metallic organic compound transferred to the defective part in the electrode.

In the above-mentioned device, if the metallic pattern is a lightproof film, it is preferable that the device is provided with a semiconductor laser for removing a part sticking out from the metallic pattern.

When the above-mentioned repairing device is applied to the lightproof film, a part sticking out from the metallic pattern needs to be removed after the metallic pattern having a defect is repaired, and if the part is not removed, the metallic pattern causes deteriorated quality as a mask. Therefore, since the part sticking out from the metallic pattern is cut by a laser applying unit such as YAG laser to prevent the deterioration of quality, even if the metallic pattern is an expensive mask made of chromium plane on the glass substrate and has a defect, it does not need to be scrapped, which can reduce costs.

Further, it is preferable that the above-mentioned device is provided with a unit for adjusting the output of the semiconductor laser.

By using the above-mentioned device, a very small amount of paste can be transferred smoothly to the defective part of the very fine electrode and a metallic thin film of high quality and having no cracks can be provided on the defective part.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the present invention may be readily ascertained by referring to the following description and appended drawings, in which:

FIG. 1A, FIG. 1B, and FIG. 1C show steps of a method for repairing an electrode according to the present invention;

FIG. 2 shows an action of a transfer probe;

FIG. 3A is a front view showing a structure of a transfer probe, and FIG. 3B is an enlarged view thereof;

FIG. 4 is a profile showing a relationship between time and output in a baking process;

FIG. 5 is a schematic view showing an electrode repairing device according to the present invention;

FIG. 6A is a plan view of an inspection device for inspecting a position of a defect of an electrode, and FIG. 6A is a circuit thereof;

FIG. 7 shows a method for forming an electrode pattern on a substrate by using a lightproof film;

FIG. 8 shows a method for repairing a defective part of a metal pattern;

FIGS. 9A to 9C are plan views of electrodes formed on a substrate, in which FIG. 9A shows normal electrodes, FIG. 9B shows an electrode having a short-circuited defect, and FIG. 9C shows an electrode having a broken defect.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A substrate having an electrode repaired according to the present invention will be described with reference to the drawings.

FIG. 1A, FIG. 1B, and FIG. 1C schematically show steps of a method for repairing a broken defect, FIG. 1A shows a state in which paste 1 comprising metallic organic compound is applied

on a broken defective part 6, FIG. 1B shows a state of heating the paste 1, and FIG. 1C shows the repaired state of the broken defective part 6 after heating.

In FIG. 1A, a substrate 10 shows a state of the substrate before repairing, in which paste 1 comprising metallic organic compound and an electrode 3 are laminated on a glass substrate 2. The above-mentioned glass substrate 2 is an ordinary substrate, and the above-mentioned electrode 3 is made of ordinary material of ITO or the like and is formed in a line by patterning and etching on the glass substrate 2 in an equal width and in an equal pitch. Further, paste 1 comprising metallic organic compound is formed by a transfer unit 4 in the broken defective part 6 of the electrode 3 formed on the glass substrate 2. The broken defective part 6 is made in the electrode 3 by a foreign substance mixed in the film plane of ITO or the like when the electrode 3 is formed by etching (see FIG. 9C).

The above-mentioned transfer unit 4, as shown in FIG. 2, comprises a transfer probe 4a, a base 4d having a receiving part, and a plate frame 4c. The paste 1 is poured in the plate frame 4c and is leveled off by a squeegee to make a plate paste 1c. Further, the above-mentioned transfer probe 4a is provided with a moving unit 13a (see FIG. 5) and can be freely moved between the broken defective part 6 and the plate paste 1c.

FIG. 2 shows an action of the transfer probe 4a and a predetermined amount of paste 1 is transferred to the tip end

of the transfer probe 4a in the following actions: the transfer probe 4a is moved from an initial state (a) above the plate paste 1c (b) and is lowered there (c), then, the transfer probe 4a is pressed on the plate paste 1c until it reaches the bottom thereof and then the transfer probe 4a is moved up, whereby a predetermined amount of paste 1 is transferred to the tip end of the transfer probe 4a. In this regard, as shown in FIG. 3A, the transfer probe has a coil spring 7 as an elastic body in itself and when the transfer probe 4a reaches the bottom of the plate paste 1c, the coil spring 7 is pressed by a force F against the urging force of the coil spring 7 from above the transfer probe 4a. Next, the transfer probe 4a is moved above the broken defective part 6 of the glass substrate 2 (d) and is lowered there (e). Then, the transfer probe 4a is moved up to separate the paste 1 from the transfer probe 4a, whereby the above-mentioned paste 1 is transferred on the broken defective part 6 and the step returns to the initial state (f).

Further, it is recommended that the material of the above-mentioned transfer probe 4a be beryllium-copper, and that the tip end of the transfer probe 4a has a flat shape 4b to easily transfer the paste 1 to the tip end.

By employing the transfer probe 4a described above, a predetermined amount of paste 1 can be always transferred without a positioning mechanism or controller of high accuracy. Further, the amount of paste 1 to be transferred is changed easily by

changing the depth of the plate paste 1c.

The above-mentioned paste 1 comprising metallic organic compound is not gold powder-based gold paste but organic matter combined with gold atoms, and is formed in liquid paste. It is preferable to use gold paste of gold-resinate-based MOD (metalloorganic deposition) type as the paste 1 like this, and in particular, gold paste for low temperature baking. The substrate 10 before repairing whose broken defective part 6 is filled with transferred paste 1 as described above is carried to a step shown in FIG. 1B and the paste 1 is baked there.

A semiconductor laser 5a is employed as a heating source of a heating unit used for baking and irradiates the paste 1 with near-infrared rays having a wavelength of approximately 810 nm to bake the paste 1. In this respect, although not shown, the above-mentioned semiconductor laser 5a is constituted by a plurality of semiconductor elements, that is, beams of laser light radiated from the semiconductor elements are bundled by glass fibers and are converged by a lens unit and radiated on an object.

When the above-mentioned semiconductor laser 5a is used, as shown in FIG. 1B, laser light radiated on the paste 1 is absorbed to heat the paste 1, but laser light radiated on the other part is not absorbed but passes through the electrode 3 and the glass substrate 2. That is, the semiconductor laser 5a uses an element radiating near-infrared rays and the near-infrared rays are

absorbed by the paste 1 because the paste 1 is black. Only the transferred paste 1 is heated and the other part of glass substrate 2 is not heated and hence is not damaged.

Further, the semiconductor laser 5a can easily control the intensity of laser output to make the broken defective part 6 can a baked part of high quality after the paste 1 is baked.

A profile shown in FIG. 4 is a heating process for producing a baked part of high quality described above. In FIG. 4, a horizontal axis designates time and a vertical axis designates laser output per unit area.

First, a laser output is increased to a predetermined value (0 to 8 sec) and then is held at low values for predetermined periods (8 to 16 sec, 16 to 24 sec) to provisionally bake the paste 1, whereby solvent contained in the liquid paste 1 is dissipated. Then, the laser output is held at a high value for a predetermined period (24 to 34 sec) to bake the paste 1 in earnest, whereby metallic components are deposited. After baking the paste 1 is finished, the laser output is decreased gradually (34 to 42 sec) to cool the paste 1. When the paste 1 undergoes the treatment described above, a metallic deposit formed in the defective part 6 becomes a high-quality metallic film 1a having no crack and a dense texture. In this regard, the above-mentioned profile is an example and can be changed according to the amount of transferred metallic organic compound.

The broken defective part 6 is repaired in this way to

produce a metallic thin film 1a made of metallic deposit as shown in FIG. 1C, which produces a repaired substrate 10a.

As described above, the method for repairing the defective electrode on the substrate according to the present invention comprises steps of, transferring the paste 1 comprising metallic organic compound on the broken defective part 6 produced in the electrode 3 on the glass substrate 2 by the transfer unit 4, and baking the paste 1 by the heating unit 5 comprising the semiconductor laser 5a to deposit only the metallic component contained in the paste 1.

FIG. 5 is a general view of a device for inspecting and repairing the defective electrode 6 on the electrode substrate 10.

The device comprises a table 12, an inspection unit 8, a transfer unit 4, and a heating unit 5. The table 12 is a table on which the glass substrate 2 having an electrode 3 is placed and can be moved freely in the direction of X, in the direction of Y, and in the rotational direction (θ) to compensate the position of the glass substrate placed on the table 12.

The above-mentioned inspection unit 8 has an inspection probe 8a and an inspection brush 8b and these parts are connected to an inspection circuit 8c and a moving unit 13c and are controlled by a control unit 11.

FIGS. 6A and 6B are schematic views showing the inspection unit 8 for identifying the position of the broken defective part

6, in which FIG. 6A is a top view and FIG. 6B is a side view. In this respect, the above-mentioned inspection brush 8b has a width such that it covers neighboring electrodes 3 and hence even if the inspection brush 8b is shifted slightly in the transverse direction, an inspection error is not caused.

First, when the glass substrate 2 on which electrodes 3 are formed is placed on the table 12, the inspection probe 8a and the inspection brush 8b are placed on both sides of the electrode 3 to inspect the electrodes 3 formed in lines one by one. The inspection probe 8a and the inspection brush 8b are joined to the inspection circuit 8c. The inspection unit 8 is constituted by an electric power source E, a resistance R, and a voltmeter for measuring voltage across the resistance R and each end of the inspection unit 8 is joined to the inspection probe 8a or the inspection brush 8b, respectively. In the inspection unit 8, when the electrode 3 is normally formed, electrical continuity is produced in the electrode 3 to produce voltage across the resistance R formed in the inspection circuit 8c, and when the broken defective part 6 exits in the electrode 3, electrical continuity is not produced and hence voltage is not produced across the resistance R. Therefore, the broken defective part can be checked by monitoring the voltage (V) across the resistance R.

If the electrode 3 having the broken wire defect is identified, the inspection brush 8b is moved toward the

inspection probe 8a to identify the position of the broken defective part.

As shown in FIG. 6B, the inspection brush 8b is slid from a state (a) toward the inspection probe 8a (in the direction of a state (d)). When the inspection brush 8b is at a state (b) before the broken defective part 6, voltage across the resistance is not produced and when it is at a state (c) after the broken wire defect 6, voltage across the resistance is produced, whereby the position of the broken defective part 6 is identified. In this way, it is possible to correctly identify the line and the place where the broken defective part 6 is produced.

If the broken defective part 6 is detected, the transfer unit 4 is operated. The transfer probe 4a of the transfer unit 4 is connected to the moving unit 13a and is controlled by the control unit 11 such that it can freely move between the plate paste 1c and the broken defective part 6.

The paste 1 is transferred to the broken defective part 6 by the above-mentioned transfer unit 4 and then is baked by the heating unit comprising the semiconductor laser 5a. The semiconductor laser 5a is connected to a moving unit 13b and is controlled by the control unit 11 such that it can freely be moved above the paste 1 transferred to the broken defective part 6.

As described above, since the electrodes 3 on all the lines are inspected and repaired, the substrate can be used as a good product.

Further, the present invention is not limited to the above-mentioned preferred embodiment, it can be applied to, for example, repairing a lightproof film formed on a mask for forming an electrode on a glass substrate, or on a mask substrate for forming a semiconductor.

FIG. 7 shows a method for forming an electrode pattern on a substrate by using a lightproof film (mask).

FIG. 8 shows a method for repairing a defective part of a metallic pattern in the lightproof film (mask).

A mask 20 shown in FIG. 7 is formed by providing a lightproof film 22 formed by a metallic pattern on one side of a glass substrate 21. The lightproof film 22 is formed by depositing the metallic pattern by sputtering chromium (Cr).

When the above-mentioned mask 20 is used for a liquid crystal display substrate, an electrode formed of ITO or the like can be formed on a substrate 2 for a liquid crystal. That is, as shown in FIG. 7, in a substrate in which the glass substrate 2, the electrode layer 3 and a resist layer 15 are laminated in sequence, the above-mentioned mask 20 is placed on the resist layer 15 and is exposed to light and is developed in a state shown in FIG. 7 to remove the part except the part covered by the lightproof film 22 of the resist layer 15, whereby a resist pattern is formed. Further, the electrodes 3 except the resist pattern is removed by etching. Then, the electrode formed by the metallic pattern is formed on the glass substrate 2 by removing the

remaining resist layer 15 on the lightproof film 22.

While the above-mentioned mask 20 is manufactured, the metallic pattern is formed on the glass substrate 21 as the lightproof film 22, and sometimes a defective part 24 shown in FIG. 8 might be formed thereon. Therefore, paste 23 is transferred to the defective part 24 and is baked to repair the defective part 24.

In this case, the same metallic organic compound described above, to be more specific, gold paste of gold-resinate-based MOD (metalloorganic deposition) type can be used as the paste 23.

The same semiconductor laser described above can be used for baking the paste 23 and the wavelength of the laser ranges within near-infrared rays. In this regard, the glass substrate 21 is hard to suffer damage because it is baked by the semiconductor laser (near-infrared rays). That is, since the above-mentioned laser light passes through the glass substrate 21 and is absorbed by the lightproof film 22, there is little difference in temperature between a part of the paste 23 transferred to the glass substrate 21 and a part of the paste 23 transferred to the metallic plane of the lightproof film 22, and hence both parts are uniformly heated, which prevents a problem caused by a difference in the solidification of the parts.

The defective part repaired in a manner described above sometimes has a part sticking out from the metallic pattern of

the lightproof film 22 (the diagonally shaded area in FIG. 8) and the part sticking out from the metallic pattern is required to be removed because the quality as the mask 20 is deteriorated in this state (in the case of the electrode, the part sticking out from the metallic pattern is acceptable, if the part is not short-circuited). To remove the sticking out part, a device for applying laser rays such as YAG laser rays is used.

The repairing device according to the present invention is provided with a laser applying device for applying laser rays such as YAG laser rays.

According to the present invention, even if a broken defective part is detected in an electrode, the defective part can be repaired by a metallic thin film of high quality to have good electric characteristics, which can prevent the defective part from being heated and causing damage to a substrate.

Further, according to the present invention, only paste placed in the defective part is heated and the other part is not heated by using a semiconductor laser for baking the paste, and hence the substrate does not suffer damage. Furthermore, the metal in the defective part is treated by a baking process comprising provisional baking and main baking and a cooling process, and hence a dense metallic thin film with no crack can be produced.

Still further, since both of the transfer unit and the heating unit according to the present invention can be made very

compact and can be attached to a conventional device now in operation, they have good general versatility. Since a semiconductor laser is used as a heating unit, it can eliminate drawbacks of a conventional laser unit, such as short life and difficult handling.

In addition, the present invention can compensate a lightproof film of a mask.

Many widely different embodiments of the invention may be constructed without departing from the spirit and the scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.